§8. Planing and Construction of Furnace Heated by Microwave with 120kWat 2.45GHz

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1.Introduction

The present works have aimed the effective and rapid production of pig iron from powdery iron ore and carbon materials using microwave heating. Then, the furnace heated by microwave with 120kW at 2.45GHz has been developed.

2.Experimental

The load chamber was a steel cylinder with 1.2 m diameter and 1m depth. The bottom with 50cm thickness and wall with 10cm thickness inside of the chamber was constructed of castable alumina cement. The inside of a steel lid was covered with alumina board. The inside of the bottom, wall and lid was lined with graphite seat in order to reflect microwave. 4 systems of 30kW crystron generators (Toshiba E3739B, 2.45GHz) were installed. Each generator had a silica window, a water-cooled isolator, a 3-stab auto tuner (VSWR1.01-1.17, PC control) and directional coupler on the wave guide. The end of wave guide was cut slantingly to radiate microwave into the center of bottom and cooled with water. 4 generators were modulated with wave shift to make uniform microwave field. Nitrogen gas of 50 l/min was flowed from each silica window in order to adhere powder.

The supplier of mixture of magnetite ore powder and 11 mass% of graphite powder was set on the lid. Out gas was burned with a burner.

A cylindrical crucible of MgO was employed with 300 mm inside diameter, 500 mm height and 10 mm wall thickness. The center of crucible bottom had a hole with 100 mm diameter and the crucible was set on a MgO-C plate. Molten pig iron was flowed out through the hole and space between the crucible and the plate. The crucible was separated with alumina boards in order to prevent the wave guides from contaminating with powder, as shown in Figure 1.

Figure 1 Load chamber for 120kW at 2.45 GHz and reaction furnace

2kg of resources was initially supplied and then microwave was applied with increasing power gradually. When luminescence was radiated from the reaction furnace, resources was continuously supplied.

3.Results

Figure 2 shows a product of pig iron. The supplying rate of resources was 0.1 to 0.35 kg/min. The temperature increase of out gas was about 100℃/min and attained to about 1400℃. The maximum gain of pig iron was 14.4 kg/h with the microwave power of 34 kW. The average gain was 10 kg/h. The heat loss from the radiation on the wall of load chamber was about 14 kW. (Plan was 9.5 kW). Taking into account of the heat loss, the net microwave power used to produce pig iron was 20 kW. The theoretical gain was 24.5 kg/h that was 0.72 kg/kW/h. Thus, the maximum efficiency of pig iron making was 58% and the average was 40%.

The heat loss of 14 kW from the wall of load chamber should be decreased. The insulating system of chamber is to be improved. The alumina board just front of the exit of wave guide had the marks of microwave transfer. This means that microwave was radiated in one direction.

4. Conclusions

Microwave is coherently electromagnetic. Materials absorb microwave to heat themselves and radiate radiant heat with random modes. Also, a part of microwave directly gives the energy of chemical reactions and transformation of crystal structure. This indicates that the efficiency of material production could be increased more than conventional processes. However, the physical principle of the microwave effects has not been realized adequately. From the view point of decrease of CO_2 gas emission that is the cause of globe warm, the conventional energy of high temperature gas used for modern industries should be replaced to electricity and saved.

Figure 2 produced pig iron